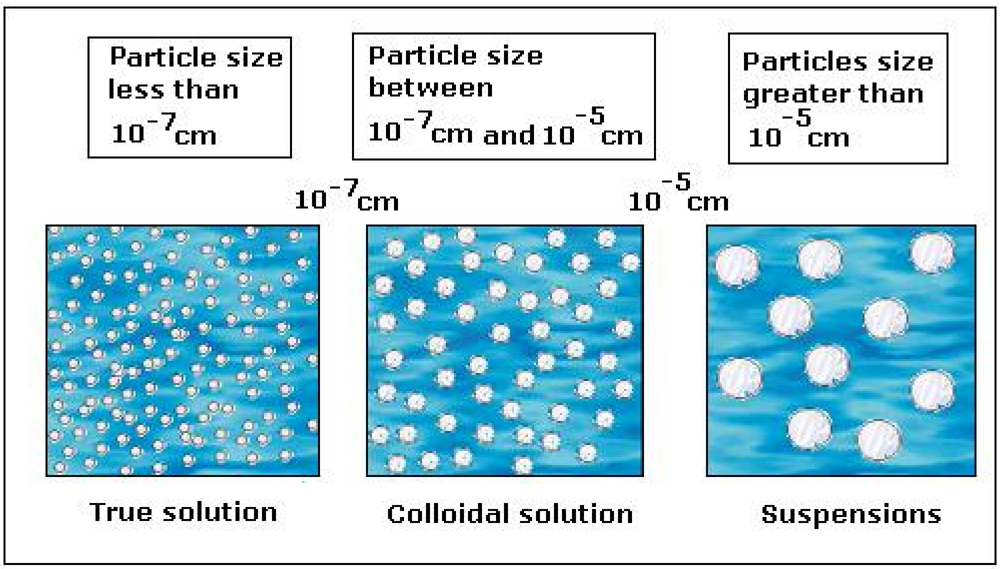
Here's why

A lot of chemical processes take place while the reactants are in solution, usually a water solution.

Mixtures

- Mixtures are ____
  ____
- mixtures can be separated into their components ______________________
  ____
- Mixtures come in the form of solutions, suspensions, or colloids.



Suspensions

- Suspensions____
- Example: ________________________

Colloids

- Colloids are substances where__________________________________
  ____
- Example:________________________

Solutions

- Solutions are ____
  ____
- Example: ________________________Comparison chart solution, suspensions & colloids & solutions

	Solutions	**Colloids**	**suspensions**
Type mixture	Homogenous	Heterogeneous	heterogeneous
Particle size	0.1nm-1nm	1-1000nm	>1000 nm
Particles settle out	NO	NO	YES
Can be separated by filtering	NO	NO	YES
Scatter light	NO	YES	May

Other mixtures

- An **aerosol** is a ____
  ____
  - Examples:____
- An **emulsion** is a mixture of ____
  ____(not mixable).
  - Examples:____

- Emulsions are________________. Although the terms *colloid* and *emulsion* are sometimes used interchangeably.
  - Examples:____

- A **foam** is a substance that is ____

  ____

- Examples: ____

- In most foam, the volume of gas is large, with thin films of liquid or solid separating the regions of gas.

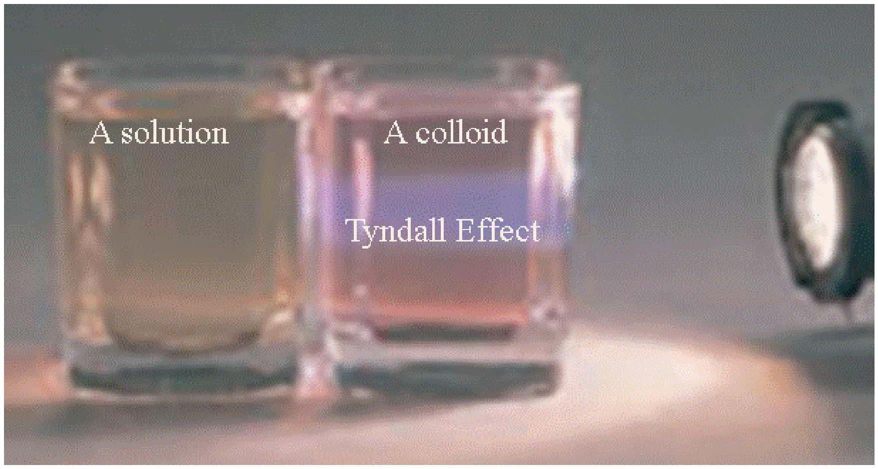
Testing for true solutions

.___________________________exhibit light scattering.

- A beam of light or laser will trace a ______________________through a genuine colloidal suspension.
- Example: ____
- a beam of light or laser light will not trace a visible path through a true solution

Tyndall Effect (If you really want to know)

- Tyndall scattering occurs when the dimensions of the particles that are causing the scattering are larger than the wavelength of the light that is scattered.
- It is caused by reflection of the incident light from the surfaces of the particles.



In true solutions, the solute will not come out of solution without a change in temperature or pressure.

The parts of a solution

- all solutions have two basic parts.
- They are:
  - 1. Solute which is the ____

    ____
  - 2. Solvent which is the ____

    ____
  - 3. The substance in greatest percentage is usually considered to be the___

    ____

Nine combinations of solvents & solutes

Solvent	Solute	Example
Gas	Gas	Air
Liquid	Gas	Soda
Solid	Gas	Hydrogen on Pt
Gas	Liquid	Water vapor in air
Liquid	Liquid	antifreeze in water
Solid	Liquid	Cu in Hg
Gas	Solid	C in air (soot)
Liquid	Solid	Sugar in water
Solid	Solid	pewter

Solvents & Solutes

- The ability of a solute to mix with a solvent is called____________________.
- Some solutes are only slightly soluble in a given solvent
- Some solutes are very soluble in a given solvent.
- This appears to depend on the _____________________________________ ______.

“Like dissolves like”

- A General rule applied to solute-solvent relationships goes like this: “ Like dissolves like”
- There are two types of solutes and solvents.
  - They are polar and nonpolar.
- SO_______________ solutes will dissolve in_____________________ solvents
- And ___________________solute will dissolve in ______________________

  solvents.

And there are some substances that can be both polar and nonpolar because of molecular structure

- Solvents can be selective about what solutes they will dissolve due to electronic structure.

Solutes, Solvents & Conditions

- Generally three things affect the solubility of a solute in a solvent.
  - They are:
    - .__________________________________
    - .__________________________________
    - .__________________________________

Some solutes such as gases will respond to ______________&________________

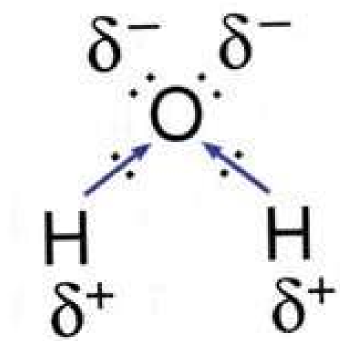
Solid solutes will not be affected by _______________but are very sensitive to ________

Solvent molecular structure

- Water is a________________________________.
- Water is the ________________________
- Water is polar because of the____ ______
- This occurs because oxygen does____

- The electrons from the hydrogen atoms spend most of the time close to the ____
____

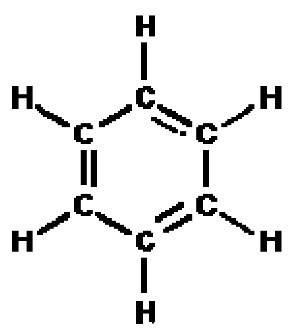
- This creates a ______________________charge (pole) on the oxygen atom and a ____________charge (pole) on each of the hydrogen atoms.



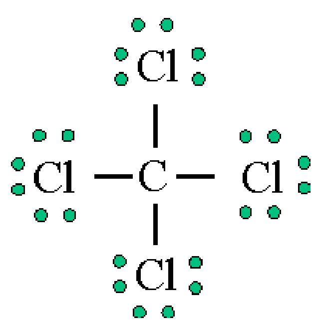
Nonpolar solvents

- Some organic substances such as carbon tetrachloride and benzene are nonpolar solvents.

The nonpolar solvent benzene



Carbon tetrachloride

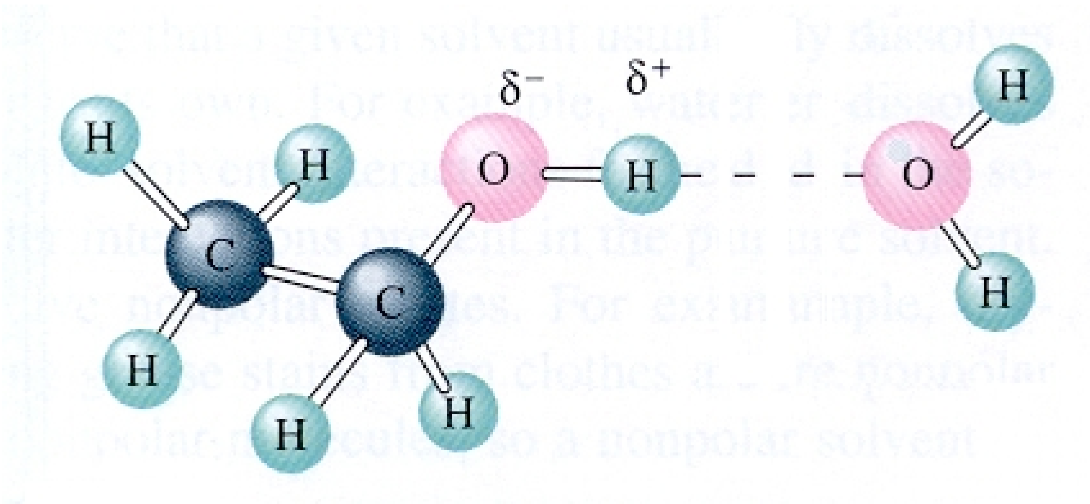


- This is due to an ____
- Therefore they will dissolve_______________________ solutes and will not dissolve ______________________compounds.

Solvents that is both polar & nonpolar

- Alcohols such as methanol, ethanol, and glycols (antifreeze) are both polar and nonpolar.

- The functional group of the alcohols is______________________________.
- The electronegativity of oxygen is substantially greater than that of carbon and hydrogen.
- The covalent bonds of this functional group are polarized so that oxygen is electron rich.



Solutes & Solvents Summary

- Generally **polar solute** molecules will **dissolve** in **polar solvents**
- **Non-polar solute** molecules will **dissolve** in **non-polar solvents**.

Solutes & Solvents

- The polar solute molecules have a ___________________________end on the molecule.
- If the solvent molecule is also____________________, it will have a positive and negative end.
- The opposite ends of the 2 types of molecules will attract. (plus to minus and minus to plus)

- This is a type of intermolecular force known as______________________________
- All molecules have a type of intermolecular force much weaker than the other forces called______________________________.
- This gives the non-polar solvents a chance to solvate the solute molecules.

Le Chateliers Principle applied to solutions

- Most solutions will achieve an equilibrium ______________________________
  ____
- However, when a stress occurs the equilibrium will find a new set of conditions.
- Stresses that can be applied to a solution:
  - .____
  - .____
  - .____
  - .____
- The solution will make adjustments to the change in conditions.

Equilibrium & saturation

- Saturation is ____
  ____
- If the conditions are stable (not changing) then the _________________________
  ____
- The conditions are said to be at____
- Saturation at equilibrium is _______________________meaning that the saturation point will change if the conditions change.
- It means that same amounts of solute will move in and out of solution.

- If the system is at equilibrium then equal amounts of solute will dissolve and recrystallize at the same time.

Equilibrium & Saturation & Change

- Depending on the direction of the change in the equilibrium two things can happen.
  - First some of the solute may come out of solution
    - .____
      ____
    - .____
      ____
  - Second the equilibrium may move in a direction to __________________
    ____
    ____
    ____

Solubility redefined

- Therefore we must adjust the definition of solubility to include conditions.
- Solubility is ____
  ____
  ____

Saturated and unsaturated defined

- At a given set of conditions:

a solution that can hold the maximum amount of solute is said to be ***saturated*****.**

a solution that does not have the maximum amount of solute is said to be ***unsaturated.***

The effect of pressure on solutions

1. Pressure has ____________________effect on **liquid/liquid** solutions.

2. Pressure has ____________________effect on **solid/liquid** solutions.

3. Pressure has_____________________effect on **gas/liquid** solutions.

Gases in Solution

- As the pressure on the gas over the solution______________; the concentration of the gas in the solution___________________.
- This system follows two laws.
  - Le Chateliers Principle
  - Henry's Law which states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas above the liquid.
- .______________________ the pressure of a gas over a liquid and more gas will dissolve in the liquid
- This will *increase* the______________________ of the gas in the solution.
- .______________________the pressure of the gas over the liquid and some of the gas will come out of solution.
- This will _____________________the concentration of the gas in the solution.

Why did my soda explode?

- If the pressure is quickly released, the gas will rapidly come of solution.
- The rapid release of a gas from a gas/liquid solution is called _________________
- Best example: ______________________

Gas/gas solutions & Dalton's Law of Partial Pressure

- If you have a mixture of gases as the solute in a gas/ liquid solution, the solubility of each gas solute is _____________________________________.
- Or each gas dissolves to the same extent that it would if the other gases were not there.

The effect of temperature on solutions

- Some general things about solubility and temperature.
  - The solubility of a gas ____________________as the temperature of the solvent increases.
  - Temperature has _______affect on liquid/liquid solutions.
  - Generally, increasing the temperature _____________the solubility of solids in liquids.
  - Another way to say this is increasing temperature increases ____________

What three conditions affect the solubility of a solid in a liquid?

- They are:
  - .____
  - .____
  - .____
- Temperature has the________________ effect on solids in liquid systems.
  - When temperature is _______________the dissolving process increases.
  - This happens because there is **more kinetic energy in all if the particles involved and attractive forces are more easily overcome.**

3 ways help to increase the rate at which a solid will dissolve in a liquid

- 1. ____
- 2. ____
- 3. ____

Why do these three methods work?

- 1. ____
- 2. ____
- 3. ____

The mechanics of dissolving a solid in a liquid (water)

- Three actions occur:
  - 1. Solute particles are separated (endothermic process)
  - 2. Solvent particles are moved apart to make room for the solute particles (endothermic process)
  - 3. Solute particles are attracted to the solvent particles (exothermic process)

Energy involved in the dissolving process

- 1. separating solute particles requires energy (endothermic process)
- 2. moving solvent particles apart to make room for the solute particles requires energy

  (Endothermic process)
- 3. Solute particles attracted to the solvent particles releases energy

  (Exothermic process)

What happens doing energy changes in the dissolving process?

- Net change is______________________, **temperature decreases** as solid dissolves and **solubility increases as temperature increases.**

- If net change is_____________________, **temperature increases** as solid dissolves and **solubility decreases with increasing temperature**

Entropy and dissolving related

- Back to the entropy and lower energy state thing.
- Natural processes tend to go toward a lower energy state.
- If a dissolving process is endothermic; it is because the entropy of the system increases.

- Dissolving a gas into a liquid produces a decrease in entropy and is also exothermic.
- **So, solubility should decrease with increasing temperature and does.**

Heat of solution

- The heat of solution is ____
  ____
- is measured in kilojoules per mole of solute dissolved in a specific number of moles of solvent,
- If **dissolving is endothermic**, the heat of solution is________________
- If **dissolving is exothermic**, the heat of solution is__________________

Some other things going on in solutions

- Solvation is the process by which particles of the solvent pull particles of solute away from the solute crystal.
- Hydration occurs when molecules of water surround particles of solute ill solution.

The terms miscible &immiscible

- They apply to liquid/liquid solutions
  - Miscible means the two liquids will ______________________
    - example: ____________________________________
  - Immiscible means the two liquids will ___________________
    - example: ____________________________________

Concentration

- Concentration is ____
- These are qualitative terms and are relative (subject to personal interpretation).
    - **Concentrated** means a _____________amount of solute in the solution
    - **Dilute** means there is a _____________amount of solute in the solution.
- ._______________________uses numbers to express the amount of solute in a given amount of solution or solvent.

Three main quantative terms for concentration

- – three main terms used are
    - percent by weight,
    - moles per liter of solution (molarity)
    - moles per kilogram of solvent (molality).

Supersaturation defined

- Supersaturation is defined as a condition where an excess amount of solute remains in solution at a lower temperature.
    - – This condition is unstable.
    - – It is so unstable that even a slight tap on the container or addition of a small crystal will cause the excess solute to precipitate out of solution.

Colligative properties

- Colligative properties depend only on _______________________________________

  ____
- Non-colligative properties depend on the identity of the dissolved species and the solvent.

Four colligative properties

- There are four:
  - Vapor pressure changes
  - Freezing point depression of the solvent
  - Boiling point elevation of the solvent
  - Osmotic pressure

Why do these properties change?

- The reason for the change is because ____

  ____
  - Example: freezing particles of solvent __________________________________

    ____

Vapor pressure change

- As solute is added to a solvent, the vapor pressure over the liquid will increase which will increase the boiling point.
- The math relation looks like this:

$$\Delta P_{vapor} \propto \mathrm{m}$$

Where ΔP_{vapor} is the vapor pressure and m is molal concentration.

Freezing point depression

- As solute is dissolved into a solvent, the freezing point of the solvent is__________
- Mathematically, the amount the freezing point (temperature) is lowered is directly proportional to the molal concentration.
- There are 3 variables needed to calculate fp depression. They are :

1. ΔT_f m where ΔT is change in temperature
2. m is molal concentration.

3. K_f is called the freezing point constant: it is the amt of change the fp will undergo for a 1 molal solution. Fp will go down.

$$\Delta T_f = (m)(K_f)(\# \; particiles)$$

Boiling point elevation

- When a solute is dissolved into a solvent, the boiling point of the solvent is

  ____

- This depends on the amount of solute dissolved into the solvent.
- the amount the boiling point (temperature) increases is directly proportional to the molal concentration.
- The math looks like this:
  - $\Delta \mathrm{T} \propto \mathrm{m}$
    - Where ΔT is change in temperature and m is molal concentration.
  - K_b is called the boiling point constant: it is the amount of change (raising) the boiling temperature will undergo for a 1 molal solution.

$$\Delta T_{bp} = (m)(K_b)(\# \; particiles)$$

Classifying Solutions

- If the solution:
  - Can conduct electricity.
  - Cannot conduct electricity.
- If the solute will:
  - Produce ions in water solution.
  - Break into molecules in water solution.

Electrolytes & nonelectrolytes

- Substances that can dissolve in water and the solution can conduct electricity are called ____________________________
- Substances that can dissolve in water and the solution cannot conduct electricity are called _________________________

Electrolytes in water solutions

- These compounds will produce ions in water solutions.

These solutions are called ____________________________solutions

Formation of ions

- Theory of ionization
  - Faraday – electricity made the ions from the solute in the solution.
  - Arrhenius – ions produced by the "ionization" of the particles of the solute.
    - Complete ionization will occur in dilute solutions
    - Dynamic equilibrium will occur in concentrated solutions (ions go back and forth between solution and molecules)

Ionic compounds dissolving

- Polarity of water very important
- Dipoles on water molecule attract the ions in the crystal.
- This brings the ions into the solution.
- Energy is released in the process (exothermic)
- Solution processes with water as the solvent is called hydration. This occurs when the ions are surrounded by water molecules.

Evaporation of the solvent

When the water evaporates, the reverse process occurs. The ions will go back together to rebuild the crystals.

Role of energy play in the dissolving process

- The energy released when ions become surrounded by water molecules is called the *heat of hydration.*
- More energy is released when small ions are hydrated then when large ions are hydrated.
- The energy released or absorbed depends on the relative amounts of energy needed
  - 1. ____
  - 2. ____

What is dissociation?

- **Dissociation** is the ____

  ____

Solubility & dissociation related

- How well an ionic compound dissociates in water is how soluble it is
- Ionic compounds have different degrees of solubility from very soluble to very slightly soluble.
- Even those ionic compounds that are *"insoluble"* will dissociate to some degree.

Slightly soluble ionic compounds

- in water:

Equilibrium will occur between the ions and the crystal

The solution will be saturated (has maximum amount of solute at a given temperature

- two slightly soluble ionic compounds in water; would look like this:

$$AgCl_{(s)} \rightleftarrows Ag^{+}_{(aq)} + Cl^{-}_{(aq)}$$

$$Fe(OH)_{3(s)} \rightleftarrows Fe^{+3}_{(aq)} + 3\ OH^{-}_{(aq)}$$

Precipitation reactions

- When two solutions of highly soluble compounds are mixed together ; they may produce a slightly soluble compound.
- This is really a double replacement reaction.
- The majority of the slightly soluble compound will ***precipitate*** or come out of solution and settle on the bottom of the container.
- The ions of the remaining compound will stay in solution as **spectator ions**.

Ionic equations

- Ionic equations show the ions of the compounds in aqueous solutions.
- The ***complete ionic equation*** shows ***ALL*** of the ***ions*** produced by compounds and the slightly soluble compound.
- The net ionic equations shows those ions(on the left) that make up the slightly soluble compound(on the right).
- The double replacement version:

$$AgNO_3 + KCl \longrightarrow KNO_3 + AgCl_{(s)}$$

- The complete ionic equation:
- $Ag^{+1}_{(aq)} + NO^{-1}_{3(aq)} + K^{+1}_{(aq)} + Cl^{-1}_{(aq)} \longrightarrow K^{+1}_{(aq)} + NO^{-1}_{3(aq)} + AgCl_{(s)}$
- The net ionic equation will look like this:
- $Ag^{+1}_{(aq)} + Cl^{-1}_{(aq)} \longrightarrow AgCl_{(s)}$

Spectator ions

- The ions that do not make up the precipitate and remain in the solution are called *spectator ions*.

Some molecular compounds conduct electricity in water

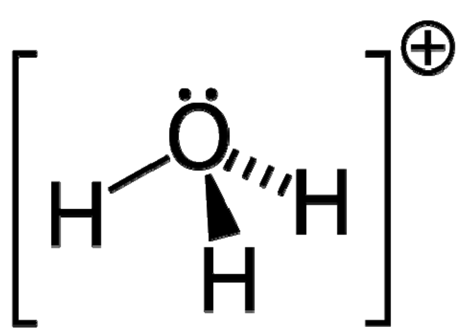
- So far in our discussion, all of the compounds have been ionic. BUT there are some molecular compounds that will conduct electricity in water solutions.

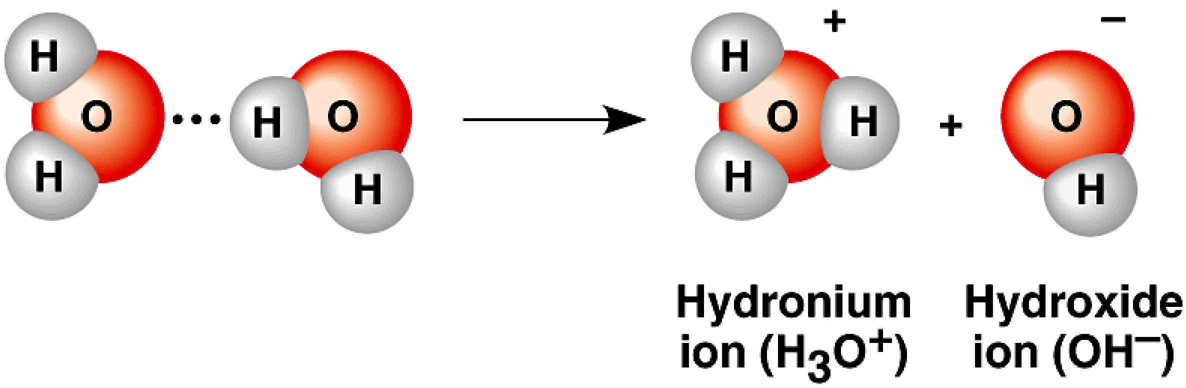
Solution process for molecular electrolytes

- When a molecule containing polar bonds is dissolved in water, the dipoles of the water attach to the charged areas of the polar molecules.
- For nonelectrolytes, the complete molecule goes into solution.
- For electrolytes, the weak _________________bonds are broken in the molecule; forming ions.
- Examples of these compounds are: ________________________________

Formation of hydronium ions

- When hydrogen ions are formed in a solution a special type of ion forms.
  - Hydrogen ions are just a proton because the electron has been removed or stayed with the more electronegative atom.
  - Hydronium ions are hydrated hydrogen ions.
    - A hydrogen ion with one_________________________.
      - The ion is written this way: H_3O^+





Strong and weak electrolytes

- A strong electrolyte is a substance that will completely ionization(come apart 100%) in dilute solution.
  - Examples: HCl and any soluble compound can exist as ions when dissolved
- A weak electrolyte is a substance that produces a low number of ions in solution.
  - Example: HF(because HF is in solution as more molecules than ions)

Some properties of electrolyte solutions

Conductivity of solutions

  - These solutions will conduct electricity.
- They will also depress the fp and elevate the bp of the solvents

Freezing point affected in electrolytes solutions

- Freezing point depression has been observed in solutions produced by electrolytes in water. BUT…….
  - Electrolytes in water appear to amplify this effect.
  - Example: ____
    - A 1 molal solution of sugar will lower the fp of a water solution to –1.86 ^{o}C.
    - A 1 molal solution will lower the fp of a water solution to approximately –3.72 ^{o}C.

What is apparent degree of ionization?

- If we carefully calculate the fp of a 1 *m* solution of NaCl we find that –3.72 ^{o}C only works at low molal concentrations.
- But at higher concentrations the fp is higher than the predicted –3.72 ^{o}C.
- So does this solute really come apart 100%?

Two things affect the apparent degree of ionization

- It appears that the number of particles (ions) and their ability to move in a solution has a lot to do with the changes in fb & bp of a solvent (in this case water).

  1. The attractive forces between the ions and the molecules have a greater effect.

  2. A number of water molecules will cluster around an ion. The number of water molecules involved depends on the charge and size of the ion.

So, the apparent degree of ionization depends on…

- The size of these ion-water clusters causes the changes.
- As with any system, equilibrium will be established. Some ions will go into solution and some will return to the solid crystal.
- The degree that this occurs is called the Apparent degree of ionization.

Water as an electrolyte

- It appears that water is a very weak electrolyte. This means that water spends most of its time as molecules.
- A few water molecules will ionize to form hydronium ions and hydroxide
  - 2 molecules in 1 billion will ionize

The ionization of water

- The equations to show this looks like this:

$$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$$

So absolutely pure water will not conduct electricity. BUT tap water will and electricity and tap water can be quite dangerous. Why?

Remember water is the universal solvent and will dissolve stuff where ever it travels!!!!!

The Debye-Hückel Theory

- The ions of solute are clustered together with ions of opposite charge.
- These clusters can act like individual particles.
- This reduces the total number of particles in the solution thus reducing the predicted effects of the ions on freezing point & boiling point.